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Experiment Station

GYPSY MOTH EGG-MASS DENSITY AND SUBSEQUENT DEFOLIATION

The relationship between insect density and subsequent defoliation is usually important among the many factors involved in deciding if, when, and where to take control action against a defoliator such as the gypsy moth. Unfortunately, the proportion of the foliage that will be removed by a defoliator in any given place and year depends not only upon the number of insects that are present, but also upon a number of other variables. Thus a particular insect density does not determine a particular defoliation level. Rather, an array of defoliation levels may result from that density; and all that one can say, unless he has quantified these other determining variables, is that each particular defoliation level within this array will have a particular probability of occurrence.

In the years 1911 to 1931, records were taken annually by personnel of the now defunct Melrose Highlands, Mass., gypsy moth laboratory on the number of egg masses present on 264 0.18-acre plots, and on the subsequent defoliation of each tree within these plots. Several published papers were based on these records,[1, 2] but the relationship between egg-mass density and subsequent defoliation was not analyzed and presented in a way that could be used in practice. Therefore I have analyzed the association between defoliation and egg-mass density that was found in the Melrose plots during the years when density tended to be high and

[1] Minott, C. W., and I. T. Guild. SOME RESULTS OF THE DEFOLIATION OF TREES. Jour. Econ. Ent. 18: 345-348. 1925.

[2] Baker, W. L. EFFECTS OF GYPSY MOTH DEFOLIATION ON CERTAIN FOREST TREES. Jour. Forestry 39: 1017-1022. 1941.

defoliation was generally evident (between 1911 and 1922), in a way that may prove to be helpful in reaching control decisions.

Procedure

Apparently the 264 observation plots were selected to represent as wide a range of environmental conditions as possible.[3] During the first few years an actual tally was made of the egg clusters observed on each tree, and a separate count was made of those found within the remainder of the plot. By the fall of 1916, however, an estimating procedure was adopted. This procedure was not described in detail. A defoliation estimate was also recorded every year for each individual tree. This latter value was the average of the independent estimates of at least two experienced observers.[4]

For my analysis the annual egg-mass counts for each plot were converted to a per-acre basis, and a mean percentage defoliation was calculated from the estimates for the oak trees in that plot. These data were then compiled in a frequency matrix, using five categories of current egg-mass density, two categories of trend in egg-mass numbers, and four defoliation categories.

Both the procedures for gathering the original data and the methods of data conversion that were used here allow for sampling bias — for example, in the initial selection of observation plots, in the method of estimating both egg-mass density and defoliation, and in the restriction of this analysis to defoliation of oaks only. These limitations will be discussed later.

Results

The number of egg masses per acre at the start of the generation is only a crude approximation of insect density in the larval stages when defoliation takes place. One reason for this is that the number of eggs per egg mass is highly variable. We know from a previous study[5] that the number of eggs per egg mass at the start of any given year is inversely correlated with the number of egg masses per acre at the start of the preceding year. Therefore, we can forecast current defoliation more accurately by using

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[3] Guild, I. T. Summary of the Observation Point Project from 1911 to 1928. Unpublished report on file at the Forest Insect and Disease Laboratory, West Haven, Conn. 1929.

[4] Guild, I. T. Forecasting Gypsy Moth Defoliation. Unpublished report on file at the Forest Insect and Disease Laboratory, West Haven, Conn. 1928.

[5] Campbell, R. W. The Analysis of Numerical Change in Gypsy Moth Populations. Manuscript in preparation, 1965.

both egg-mass density at the start of the current year and egg-mass density at the start of the preceding year than by the use of the former variable alone.

The frequency matrix derived from these data is shown in table 1. To read this matrix:

1. Determine the appropriate category of current egg-mass density per acre (0 to 500; 501 to 1,000; 1,001 to 1,500; 1,501 to 2,500; 2,501 +).
2. Determine whether the trend in egg-mass density from the preceding year to the current year was downward, or stable or upward.
3. Read the frequency of occurrence of each defoliation category (less than 25%, 25.1 to 50.0%; 50.1 to 75.0%; 75.1% +).

Suppose, for the moment, that table 1 accurately portrays the frequency of defoliation in each listed category that one would find in an average year. Further, suppose that one is able and willing to state for various field situations: (1) A tolerable defoliation level. (2) An acceptable risk of being wrong — that is, of not identifying a particular condition as intolerable when, in fact, it will be.

Given these assumptions, table 1 provides a basis for deciding, within a given risk level, whether or not a given area should be chosen for treatment. Consider two areas as an example.

Area 1 is a wooded public picnic site, and area 2 is a private woodlot under management for fuel wood production. It is decided that for area 1 a condition of not more than 25-percent defoliation will be tolerated, and that this tolerable level should not be exceeded more than 1 time out of 10. For area 2, it is decided that not more than 50-percent defoliation will be tolerated, and that the risk of error should not exceed 1 time in six.

To facilitate a decision on area 1, the data that were shown in table 1 have been regrouped in the form shown in table 2. Note that this regrouping consisted of simply summing (in column 2) the defoliation frequencies that had been listed separately in columns 2, 3, and 4 of table 1. As indicated, only the first value listed, 0.072, is less than the stipulated risk level of 0.10. Thus, area 1 should be left untreated only when there are fewer than 500 egg masses per acre in the current year and the number found is less than that recorded the year before.

A similar regrouping of the data in table 1 will facilitate a decision on area 2 (table 3). In this case, column 1 of table 3 is equal to the sum of columns 1 and 2 of table 1, and column 2 of table 3 is equal to the sum of columns 3 and 4 of table 1.

For area 2, control would always be initiated when current density is greater than 2,500 egg masses per acre. Control would never be initiated when current density is less than 500 egg masses per acre. Control would be initiated at densities between 500 and 2,500 egg masses per acre only when the current density is greater than or equal to the egg-mass density of a year ago.

Table 1. — Frequency of various ranges of percent defoliation of oaks in a year, as related to egg-mass densities per acre at the start of that year and trend in egg-mass density from preceding year to current year

Current number of egg masses per acre	Trend in egg-mass density from preceding year to current year	Frequency of defoliation at percentage rate of — (basis: No. observations)				Total No. observations
		0 to 25.0	25.1 to 50.0	50.1 to 75.0	75.1 to 100	
0-500	Down	0.928 (90)	0.051 (5)	0.021 (2)	0.000 (—)	— 97
	Stable or up	.813 (26)	.062 (2)	.094 (3)	.031 (1)	— 32
501-1,000	Down	.791 (49)	.145 (9)	.032 (2)	.032 (2)	— 62
	Stable or up	.673 (33)	.103 (5)	.163 (8)	.061 (3)	— 49
1,001-1,500	Down	.838 (31)	.054 (2)	.027 (1)	.081 (3)	— 37
	Stable or up	.621 (18)	.103 (3)	.172 (5)	.104 (3)	— 29
1,501-2,500	Down	.639 (39)	.197 (12)	.049 (3)	.115 (7)	— 61
	Stable or up	.500 (25)	.220 (11)	.160 (8)	.120 (6)	— 50
More than 2,500	Down	.560 (42)	.213 (16)	.120 (9)	.107 (8)	— 75
	Stable or up	.286 (55)	.198 (38)	.172 (33)	.344 (66)	— 192

Table 2. — Frequency of oak defoliation in two categories (0 to 25% and over 25%) in a year, egg-mass densities per acre at the start of that year, and trend in egg-mass density from preceding year to current year (from table 1)

Current number of egg masses per acre	Trend in egg-mass density from preceding year to current year	Frequency of defoliation at percentage rate of —	
		0 to 25.0	25.1 to 100
0-500	Down	0.928	0.072
	Stable or up	.813	.187
501-1,000	Down	.791	.209
	Stable or up	.673	.327
1,001-1,500	Down	.838	.162
	Stable or up	.621	.379
1,501-2,500	Down	.639	.361
	Stable or up	.500	.500
More than 2,500	Down	.560	.440
	Stable or up	.286	.714

Table 3. — Frequency of oak defoliation in two categories (0 to 50% and over 50%) in a year, egg-mass densities per acre at the start of that year, and trend in egg-mass density from preceding year to current year (from table 1)

Current number of egg masses per acre	Trend in egg-masses density from preceding year to current year	Frequency of defoliation at percentage rate of —	
		0 to 50.0	50.1 to 100
0-500	Down	0.979	0.021
	Stable or up	.875	.125
501-1,000	Down	.936	.064
	Stable or up	.776	.224
1,001-1,500	Down	.892	.108
	Stable or up	.724	.276
1,501-2,500	Down	.836	.164
	Stable or up	.720	.280
More than 2,500	Down	.773	.227
	Stable or up	.484	.516

Discussion

Percentage defoliation of oak by the gypsy moth in the years covered by this analysis was directly related to egg-mass density at the start of each year, and inversely related to the trend in egg-mass density from the preceding year. Although these relationships were not close enough to provide a useful predictive equation, a frequency matrix such as table 1 does indicate that rather clear-cut expectations of given defoliation levels can be calculated when broad categories are used.

The original defoliation estimates taken by the Melrose personnel may be somewhat lower than the actual defoliation that occurred, since these estimates, from 1916 onward, were all made during one extended trip to all of the plots. Some of the trees in severely defoliated plots may have produced a new flush of foliage by the time this visit was made. On the other hand, the gypsy moth tends to defoliate oaks more severely than most of the other species in a stand. For this reason, it seems likely that the percentage defoliation values that were used in deriving table 1 are probably higher than the average defoliation for all species in the plots.

Finally, it seems clear from our studies in northeastern New York State[5] that sparse gypsy moth populations often receive more members than they lose during the major dispersion period of the insect, which occurs during the first larval instar. Such net gains in larval numbers might account for some of the severe defoliation that was recorded even when the number of egg masses in the plot at the start of the current year was low. Of course there are other variable factors, not accounted for here, that may have altered the relationship between egg-mass density and resultant defoliation.

Since adequate data on more recent gypsy moth infestations are lacking, the accuracy of table 1 for forecasting current conditions has not been determined. With suitable data, we could check the predictive accuracy of the results shown here. And, more important, a much broader-based guide for control decisions could be developed.

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